THE EFFECTS OF DEVELOPMENT ON FIJIAN ISLAND FRESHWATER INVERTEBRATES

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The invertebrate fauna of tropical Pacific streams is composed mainly of gastropods and shrimps. Insect larvae and nymphs are a relatively small part of the invertebrate biomass. The streams are subject to flooding and siltation after logging and road making. This results in depletion of invertebrate populations. Some of the less abundant species might never recolonize impoverished, isolated steams. The lake formed by the building of the Monasavu Hydroelectric dam on Viti Levu, Fiji, has fewer invertebrates than the flooded Nanuku creek. The gastropod *Viviparus japanicus*, which was accidentally introduced with prawns for aquaculture, has become a serious problem in a fish hatchery; it is only a matter of time before the snail becomes established in a nearby river. The invertebrate fauna is being impoverished and changed by development. □*Freshwater, invertebrates, Mollusca, Crustacea, Insecta, introductions, Pacific islands, Viti Levu, Fiji, hydroelectric dam, logging, siltation.*

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Streams and rivers of Pacific Islands, which often flow in channels cut in steep hillsides, have relatively diverse invertebrate faunas. They are especially rich in shrimp and gastropod species. These insular, freshwater communities have evolved in isolation and are liable to be upset by introductions and changes caused by developments such as logging of forests, road making, the building of dams, and forest clearing for large-scale farming .

It has been argued that because Pacific island streams are prone to natural disasters such as cyclones, floods and landslides, the species that have become established are the only ones that can survive there. This notion, however, is contradicted by the abundance of introduced Cane Toads (*Bufo marinus*)and the presence of the East African thiarid snail, *Melanoides tuberculata*, on nearly all Pacific islands (Haynes, 1990).

The purpose of this paper is to present instances where development of various kinds has affected invertebrate species diversity and abundance. The examples are mainly from Fiji, one of the most developed Pacific Island countries.

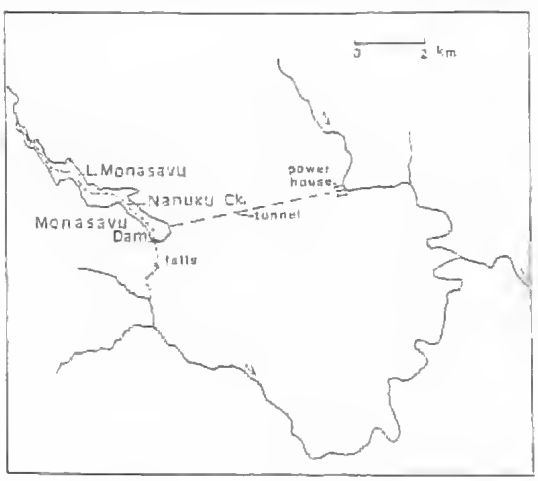

FIG. 1. Monasavu area, Viti Levu, Fiji.

THE EFFECT OF THE MONASAVU DAM

The Monasavu hydroelectric dam was constructed at an altitude of 750m in the headwaters of the Rewa river on Viti Levu, Fiji between 1977-1982 (Fig. 1). It was made of loose rocks at a site upstream from the original Monasavu falls (Fig. 2). The Nanuku valley and stream were similar to others in the inland highlands of Viti Levu. Rainforest that covered its slopes was left standing when the valley was flooded.

Before the dam's construction in April-May 1977, invertebrates were sampled just above the Monasavu falls (INR, 1977). In 1982 while the reservoir was filling, invertebrates were again sampled near the end of the construction road

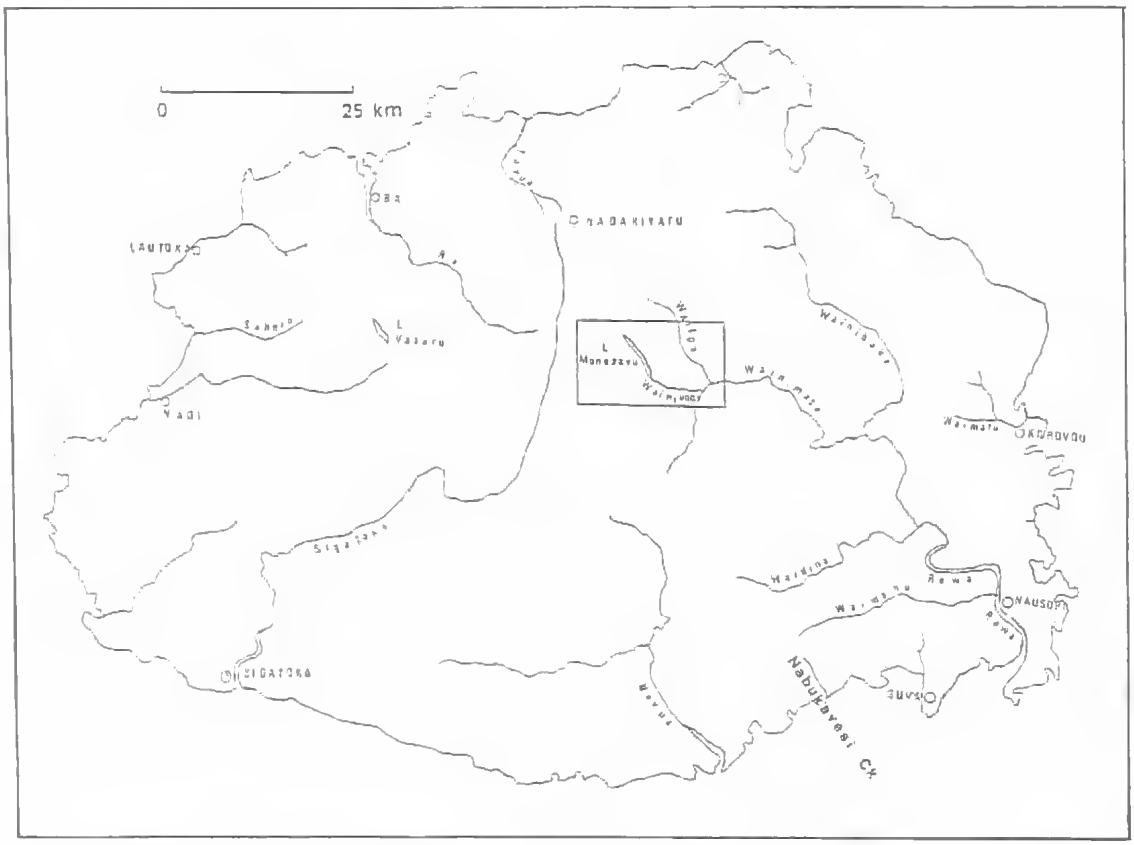

FIG. 2. Map of Viti Levu showing the main river systems and the locality of Lake Monasavu and the Nabukavesi creek. Boxed area is Fig.1 reduced.

and from the dam rocks. The same two sites (Fig. 1) were investigated for invertebrates in July 1985, 1987, 1989 and 1990.

Over this period, there were fewer invertebrates species (4-9) in Lake Monasavu than there were in Nanuku creek (19) (Table 1). Only gastropods, dragonfly and damselfly nymphs, 1 sp. leech, 1 sp. planarian and 1 sp. caddisfly had become established (Table 1). It should be noted that *Tilapia* and carp were introduced into the lake and these fish might have inhibited colononization of the lake by invertebrates.

Between 1991 and January 1993, the lake level dropped and, before cyclone Kina in January 1993, it was 20m below the 1990 level. During this period, the only invertebrates found were the benthic gastropod *M. tuberculata* and planktonic copepods.

RAIN FOREST LOGGING IN THE NABUKAVESI VALLEY

The Nabukavesi creek runs through a rugged forested valley to the coast about 30km west of Suva, Viti Levu (Fig. 2). During 1989-90, much of the accessible forest was logged. At this time the stream was discoloured and a thick layer of mud and grit covered the stony bottom.

A site in the Nabukavesi creek, about 8km inland from the Queens Road, was sampled in January 1991, 1992 and 1993. At each sampling, the means of the numbers of the invertebrate species on two lots of 15 stones (10-20cm across) were estimated.

During the January sampling times the water speed (measured by a current stick) was 30-62cms^{-1}, the stream was 10m wide and the water temperature was 23-24°C. Results for other periods: July 1992 — temperature 22.5°C, width 12m, water speed 32-66cms^{-1}; May 1993 — temperature 23.7°C, width 10m and water speed 30-55cms^{-1}. Soon after logging stopped in 1991, the number of species was small although each species was relatively abundant (Fig. 3). The net building caddis fly larvae and the clinging mayfly nymphs were the first invertebrates to appear

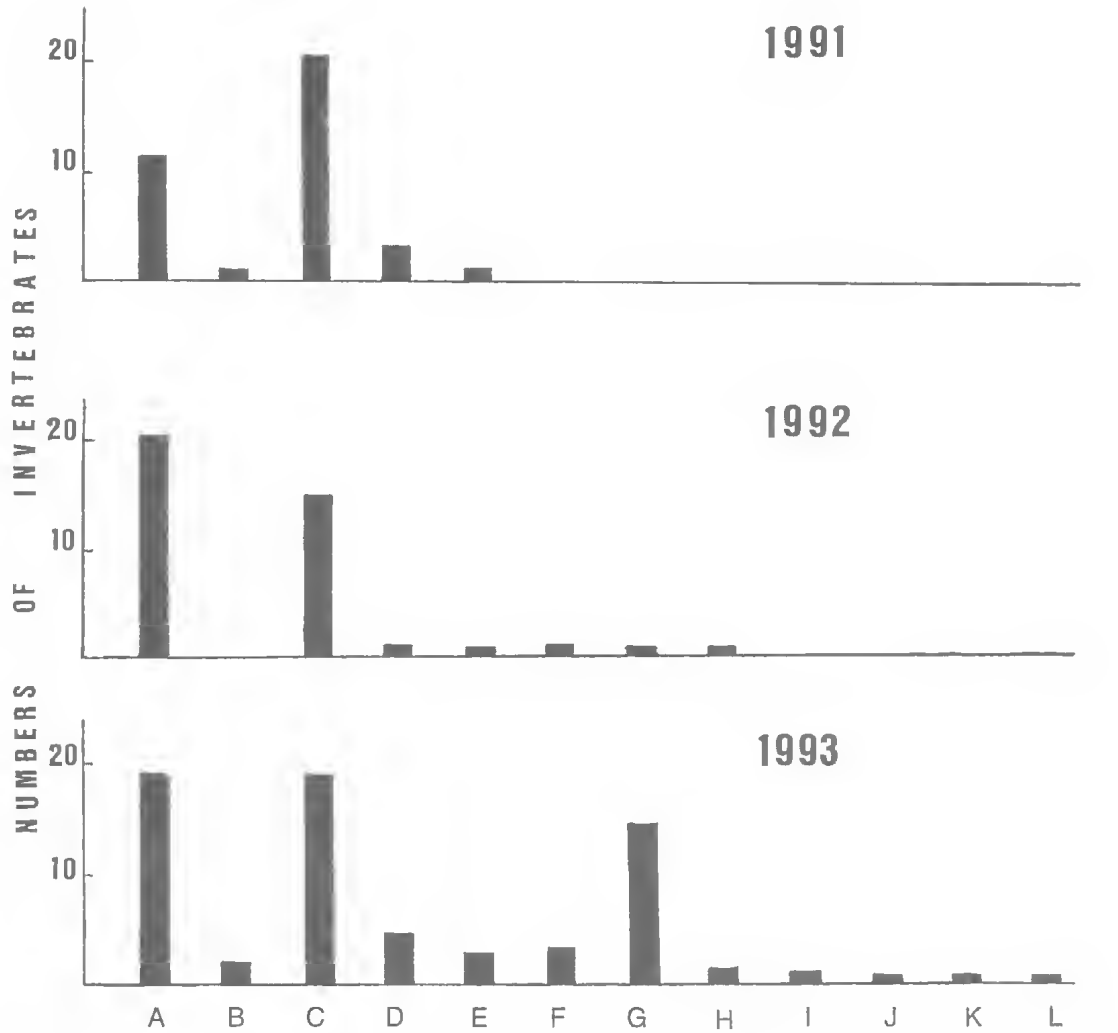

FIG. 3. The number of benthic invertebrates in the Nabukavesi creek in 1991-93: A = net caddis larvae; B = net caddis pupae; C = mayfly swimmer nymph; D = mayfly clinger nymph; E = moth larvae; F = stony-cased caddis fly larvae; G = simuliid larvae; H = damselfly nymph; I = atyid shrimps; J = secreted-cased caddis larvae; K = gastropod *Melanoides tuberculata*; L = oligochaete worm.

after most of the mud had been washed away. By 1993, 12 different species were established at the site showing that fast flowing streams do recover after sedimentation. More species of damselfly nymphs (3) and atyid shrimps (3), however, were found in the nearby Wainikovu creek where no logging had occurred.

THE INTRODUCTION OF EXOTIC SPECIES

Various species of *Tilapia*, carp and shrimps (*Macrobrachium*) have been introduced into Fiji and other island countries for aquaculture. In Fiji they are bred and kept until wanted at the Fisheries Department fish hatcheries at Naduruloulou. The shrimps and fish are given to villages that have suitable ponds for culture. So far they do not appear to have affected the indigenous fauna. However, the gastropod *Viviparus japanicus* was inadvertently introduced into the fish ponds on vegetation accompanying the *Macrobrachium* from Japan. They

TABLE 1. Invertebrates found in the Nanuku creek and Lake Monasavu after the dam was built and the valley flooded.

Invertebrates	Nanuku creek	Lake filling		Lake	Monasavu	
	1977	1982	1985	1987	1989	1990
MOLLUSCA						
Melanoides tuberculata	*			*	*	*
Physastra nasuta	*	*	*	*		*
Fluviopupa pupoides	*			*		
Ferrissia noumeensis			*			
OTHER						
leech	*	*	*	*		*
planarian	*	*		*		*
mayfly nymphs	*					
damselflies nymphs	*	*		*	*	
dragonfly nymphs	*	*		*	*	
beetle larvae	*	*				
caddis fly larvae	4 spp.			1 sp.	2 spp.	1 sp.
similiid larvae	*					
moth larvae	*					
crickets	*				*	
back swimmers	*					
water striders	*					
mosquito larvae		*				
bryozoans			*			
palaemonid shrimps	*					
green sponge				*		*

were first noticed in April 1989. By April 1991, *V. japanicus* were so numerous that they clogged two fish ponds and made them inoperable. It is only a matter of time before the gastropods reach the nearby Rewa river. Their effect on the local fauna is yet to be discovered.

DISCUSSION

The building of a dam and the impounding of a stream wiped out a whole natural community at Monasavu. Few species were found in the lake 3 years after it was filled with water, probably due to rotting vegetation producing H_2S and depressing the dissolved oxygen content of the water (INR, 1987). More species returned as decomposition of vegetation decreased but disappeared when the water level fell 20m in 1991 (Table 1).

Invertebrate species are often transient in a stream because the stream is liable to flooding during heavy rain and to siltation when hillsides are eroded after they have been cleared for farming, road building or during the logging of forests. Some of the less abundant species might be lost if they are in remote streams. The more isolated the stream the less likely it is to be recolonized (Haynes, 1990).

Many freshwater invertebrate species are widely distributed throughout islands in the Pacific but research on the islands of Fiji and French Polynesia (Resh et al., 1990) has revealed species with limited distribution. In Fiji, the gastropod *Fijidoma maculata* (Haynes, 1988) and three species of the shrimp *Caridina* (Choy,

1991) are restricted to Viti Levu while the gastropods *Fluviopupa pupoidea* (Haynes, 1985) and *Acochlidium fijiensis* (Haynes & Kenchington, 1991) are found only on Viti Levu and Vanua Levu.

Probably endemic species of stream insects also exist in Fiji but the results of development might drive them to extinction before they are discovered and described.

ACKNOWLEDGEMENTS

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